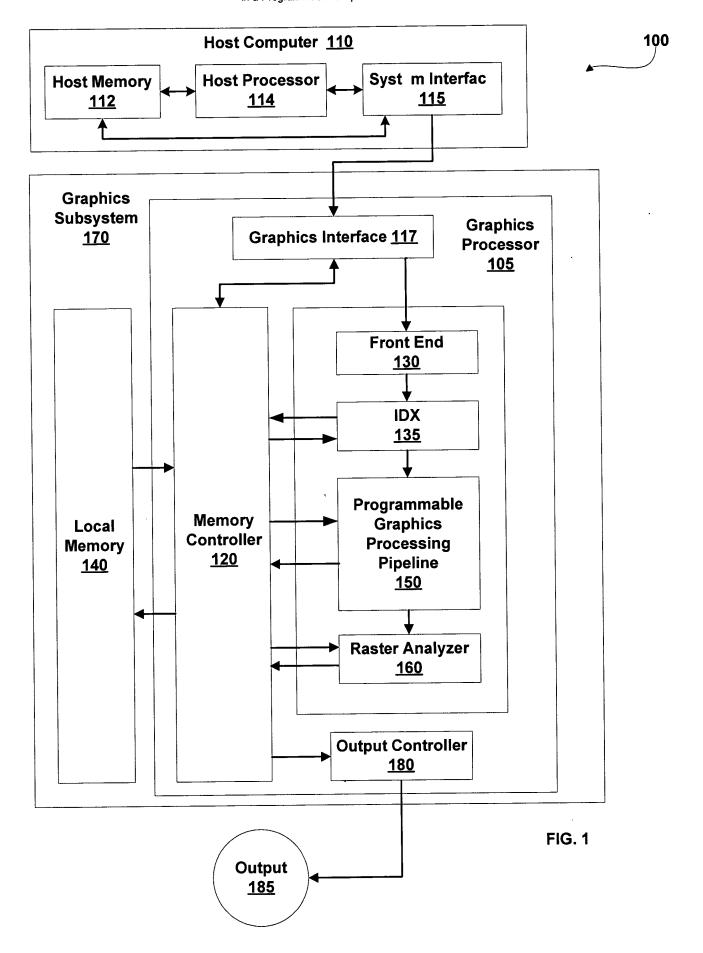P000575
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100

Host Computer 110

Host Memory 112

Host Processor 114

Syst m Interfac 115

Graphics Subsystem 170

Graphics Interface 117

Graphics Processor 105

Front End 130

IDX 135

Programmable Graphics Processing Pipeline 150

Local Memory 140

Memory Controller 120

Raster Analyzer 160

Output Controller 180

Output 185

FIG. 1

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From
135

Programmable
Graphics
Processing
Pipeline
150

Primitive Assembly/Setup
205

Raster Unit
210

Pixel Input Buffer
215

Vertex Input Buffer
220

**Execution
Pipeline
240**

**Execution
Pipeline
240**

**Execution
Pipeline
240**

**Execution
Pipeline
240**

**Texture
Unit
225**

**Texture
Cache
230**

Vertex Output Buffer
260

Pixel Output Buffer
270

To **160**

To
120

From
120

FIG. 2

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FIG. 3

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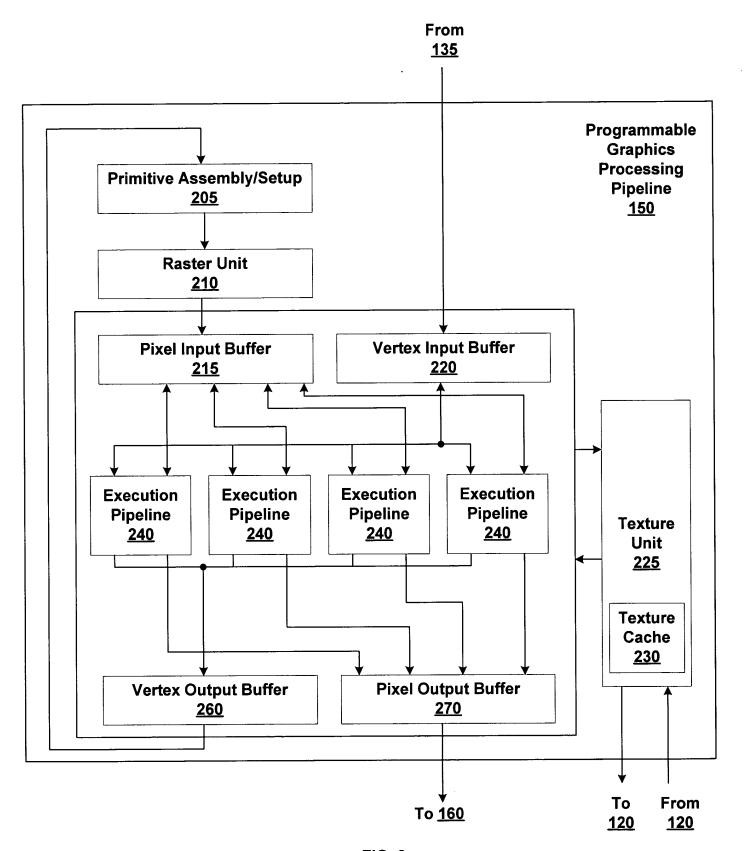in a Programmable Graphics Processor

From **215**   From **220**

Execution Pipeline 240

Multithreaded Processing Unit 400

To **225**

From **225**

Instruction Cache 410

Thread Control Buffer 420

IWU **435**

CU **433**

STU **437**

Instruction Scheduler 430

Resource Scoreboard 460

From **215**

From **220**

Instruction Dispatcher 440

Register File 450

Execution Unit 470

To **260**   To **270**

FIG. 4

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```
┌─────────────────────┐
│   Receive a Sample  │
│         501         │
└─────────────────────┘
           │
           ▼
┌─────────────────────┐
│   Receive Another   │
│       Sample        │
│         503         │
└─────────────────────┘
           │
           ▼
      ╱─────────╲                                    ┌─────────────────────┐
     ╱   Source  ╲           Y                       │ Dispatch Instruction│
    ╱ Data Available for the ╲──────────────────────▶│ for Processing the  │
    ╲      Sample?           ╱                        │       Sample        │
     ╲        505           ╱                         │         515         │
      ╲─────────╱                                     └─────────────────────┘
           │ N                                                   │
           ▼                                                     ▼
      ╱─────────╲                                          ╱─────────╲
     ╱   Source  ╲                          N            ╱   Source  ╲
    ╱ Data Available for the ╲◀──────────────┐──────────╱ Data Available for the ╲
    ╲   Other Sample?        ╱               └─────────▶╲   Other Sample?        ╱
     ╲        507           ╱                            ╲        517           ╱
      ╲─────────╱                                         ╲─────────╱
           │ Y                                                 │ Y
           ▼                                                   ▼
┌─────────────────────┐                          ┌─────────────────────┐
│ Dispatch Instruction│                          │ Dispatch Instruction│
│ for Processing the  │                          │ for Processing the  │
│    Other Sample     │                          │    Other Sample     │
│         509         │                          │         519         │
└─────────────────────┘                          └─────────────────────┘
           │
           ▼
      ╱─────────╲
     ╱   Source  ╲          N
    ╱ Data Available for the ╲◀──┐
    ╲      Sample?           ╱───┘
     ╲        511           ╱
      ╲─────────╱
           │ Y
           ▼
┌─────────────────────┐
│ Dispatch Instruction│
│ for Processing the  │
│       Sample        │
│         513         │
└─────────────────────┘
```
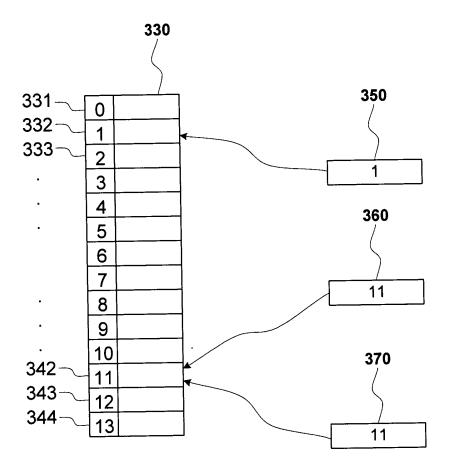
FIG. 5A

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```
┌─────────────────────┐
│   Receive Sample    │
│         520         │
└─────────────────────┘
           │
           ▼
┌─────────────────────┐
│   Identify Thread   │
│    Type Needed      │
│         521         │
└─────────────────────┘
           │
           ▼
        ◇ PIOR                          ◇ Pixel
     disabled for pixel    ─── Y ───   Thread Position    ─── Y ───┐
        threads?                          Hazard?                  │
          523                              525                     │
           │                                │                      │
           │                                N                      │
           │                                │                      │
    N ┌────┤                                │                      │
      │    ▼                                │                      │
      │  ◇ Thread  ◀────────────────────────┘                      
      └── Available?
          527
           │
           Y
           │
           ▼
┌─────────────────────┐
│    Assign Thread    │
│         530         │
└─────────────────────┘
           │
           ▼
┌─────────────────────┐
│  Allocate Resources │
│         533         │
└─────────────────────┘
           │
           ▼
┌─────────────────────┐
│  Fetch Instruction  │◀──────────────┐
│         535         │               │
└─────────────────────┘               │
           │                          │
    N ┌────┤                          │
      │    ▼                          │
      │  ◇ Can                        │
      └── Schedule?                   │
          537                         │
           │                          │
           Y                          │
           │                          │
           ▼                          Y
┌─────────────────────┐               │
│    Update PC and    │          ◇ More            ┌──────────────┐
│ Resource Scoreboard │       Instructions?  ─ N ─▶│  Deallocate  │
│         540         │           547              │  Resources   │
└─────────────────────┘            │               │     550      │
           │                       │               └──────────────┘
           ▼                       │
┌─────────────────────┐            │
│ Dispatch Instruction│            │
│         543         │            │
└─────────────────────┘            │
           │                       │
           ▼                       │
┌─────────────────────┐            │
│   Process Sample    │────────────┘
│         545         │
└─────────────────────┘
```

FIG. 5B

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in a Programmable Graphics Processor .

Instruction
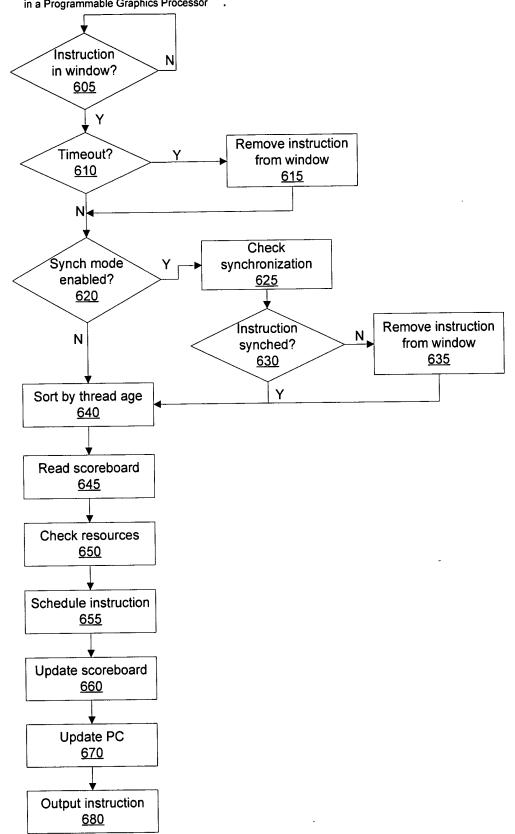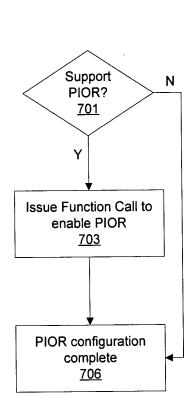in window?
605
N

Y

Timeout?
610
Y
Remove instruction
from window
615

N

Synch mode
enabled?
620
Y
Check
synchronization
625

N

Instruction
synched?
630
N
Remove instruction
from window
635

Y

Sort by thread age
640

Read scoreboard
645

Check resources
650

Schedule instruction
655

Update scoreboard
660

Update PC
670

Output instruction
680

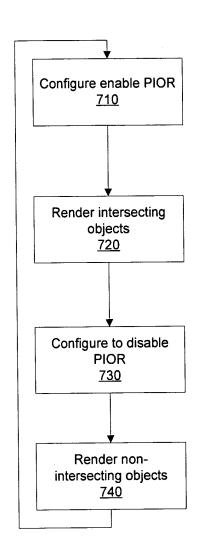**FIG. 6**

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in a Programmable Graphics Processor

Support
PIOR?
701

N

Y

Issue Function Call to
enable PIOR
703

PIOR configuration
complete
706

FIG. 7A

Configure enable PIOR
710

Render intersecting
objects
720

Configure to disable
PIOR
730

Render non-
intersecting objects
740

FIG. 7B

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in a Programmable Graphics Processor

```
      ┌──────────────────────┐
      │  Configure enable PIOR │
      │         710          │
      └──────────────────────┘
                │
                ▼
      ┌──────────────────────┐
      │  Render opaque objects │
      │         725          │
      └──────────────────────┘
                │
                ▼
      ┌──────────────────────┐
      │  Configure to disable  │
      │         PIOR          │
      │         730          │
      └──────────────────────┘
                │
                ▼
      ┌──────────────────────┐
      │  Render non-opaque     │
      │      objects          │
      │         745          │
      └──────────────────────┘
```
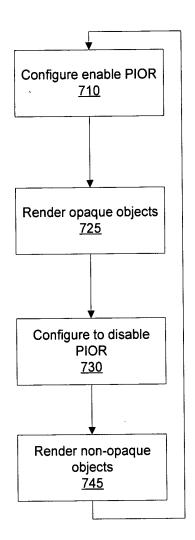
FIG. 7C